WAIS-R Subtest Pattern Clusters in Closed-Head-Injured and Healthy Samples*

J.R. Crawford[1], P.H. Garthwaite[1], D.A. Johnson[2], B. Mychalkiw[3], and J.W. Moore[4]

'University of Aberdeen, Aberdeen, [2]Astley Ainslie Hospital, Edinburgh, [3]City General Hospital, Stoke-on-Trent, and [4]Aberdeen Royal Infirmary, Aberdeen, UK

ABSTRACT

Cluster analysis was performed on the WAIS-R subtest scores of a closed-head-injured (CHI) sample *(n = 233)* in an attempt to replicate and extend the findings of Crosson, Greene, Roth, Farr, and Adams (1990). The same analysis was also run with a healthy sample *(n = 326)* recruited to match the general adult population in terms of demographic variables; a subsample matched to the CHI sample was also formed *(n = 117)*. Eleven clusters were extracted from the CHI sample, five of which contained 10 or more members. There was a low degree of correspondence between these latter clusters and the six subtest patterns clusters reported by Crosson et al. The importance of Verbal/Performance discrepancies in the formation of clusters in CHI was examined by comparing Verbal/Performance composites against arbitrary composites in CHI and healthy samples. In the CHI sample both sets of composites yielded significant effects but a larger effect size was obtained for the Verbal/Performance composites. However, the same pattern of results was observed in the healthy samples. Finally, a combined cluster analysis *(N - 559)* revealed that, although there was a significant difference in the number of CHI and healthy participants in each cluster, there was a high degree of overlap in cluster membership.

The Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) is widely employed to assess the cognitive sequelae of closed-head injuries (CHI) (Lezak, 1995; McKinlay & Gray, 1992; Richardson, 1990; Walsh, 1991). However, there has been little research on the characteristics of WAIS-R performance in CHI (Crosson, Greene, Roth, Farr, & Adams, 1990); the studies conducted to date have predominantly employed small samples and have been concerned with the WAIS rather than the WAIS-R (see Crosson et al., 1990; Richardson, 1990 for reviews). A number of authors have pointed out the dangers of assuming that research findings obtained with the WAIS will be applicable to the WAIS-R (e.g., Bornstein, 1987; Reitan & Wolfson, 1990).

Crosson et al. (1990) have conducted one of the few studies of WAIS-R performance in CHI. They performed a cluster analysis on the subtest profiles of a head-injured sample (TV = 93) with the aim of identifying common patterns of performance. Six clusters having 10 or more members were extracted and it was demonstrated that the clusters were significantly more differentiated than clusters formed from random data. It was also suggested that the presence of Verbal/Performance discrepancies played an important part in the formation of the majority of clusters. This conclusion was based on a significant interaction between clusters and VIQ versus PIQ, and significant differences between VIQ and PIQ on Tukey's contrasts for five of the six clusters. Crosson et al. noted that identification of these different clusters may prove to have

diagnostic significance and that particular patterns may be predictive of specific problems in practical, everyday functioning.

Cluster analysis is an exploratory technique and is unusual amongst multivariate methods in that groups (clusters) are formed from measures included in the analysis without reference to any external criteria. The results of any cluster analysis must, therefore, be treated with a healthy skepticism. Crosson et al. (1990) identified two issues that should be examined as a first step in establishing the clinical utility of their obtained clusters. The first issue is whether the subtest pattern clusters are observed in a cross-validation sample of CHI individuals. The second issue is whether the clusters formed in CHI individuals differ from the clusters formed in healthy samples. The present study addressed these and other related issues using WAIS-R data obtained from large samples of head-injured and healthy participants. The following are the specific questions addressed and are accompanied by their rationale where necessary:

1. Can the cluster patterns identified by Crosson et al. (1990) be extracted from a cross-validation sample of head-injured participants?

2. Compared to a healthy sample, does significantly more clustering occur in CHI and are the clusters formed more differentiated?

Crosson et al. (1990) compared the number of clusters extracted in the CHI sample with the number extracted from 93 WAIS-R profiles generated randomly by computer (scores for the random data were generated around a mean of 10 and *SD* of 3 for each subtest). They demonstrated that the number of members included in clusters with 10 or more members was significantly greater in the head-injured sample than in the random data set and concluded that the clusters in the head-injured sample were not random groupings. Crosson et al. (1990) also conducted within-cluster analyses of variance with subtests as repeated measures for the cluster extracted from the CHI sample and the random data set. They reported that, with one exception, there was no overlap between the *F* ratios obtained for the CHI clusters and random data clusters, the former *F* ratios exceeding the latter. This indicates that the CHI clusters produced more de-

fined subtest patterns than the random data set. The present study will extend this line of investigation by examining whether more clustering and greater subtest differentiation occurs with clusters in a CHI sample than in a healthy control sample.

3. What is the relative importance of Verbal/Performance discrepancies in the formation of clusters in CHI?

As noted, Crosson et al. (1990) argued that Verbal/Performance discrepancies were important in the formation of clusters because of the presence of a significant interaction and significant effects on post hoc comparisons. However, the likelihood of such significant differences is high given that the composites (the sums of the Verbal and Performance subtests) are formed from the variables used for clustering. It may, therefore, be appropriate to assess the *relative* importance of Verbal/Performance differences against the differences obtained for other composites. One suitable initial comparison would be with the differences obtained for an arbitrary allocation of subtests into two composites.

4. Are Verbal/Performance discrepancies equally important determinants of clustering in a healthy sample as in a CHI sample? Should this prove to be the case then the contribution of Verbal/Performance discrepancies to clustering in CHI would be of limited theoretical or practical interest.

5. Is neurological status an important determinant of cluster membership?

Crosson et al. (1990) noted that the clusters identified in their CHI sample may prove to be of diagnostic and localizing significance and that cluster membership may be predictive of specific difficulties in everyday functioning. The case for the utility of clusters would be strengthened if it could be demonstrated that they reflected characteristics of head injury per se. In the present study cluster analysis will be performed with *combined* healthy and CHI samples to examine whether clusters consisting predominantly/ exclusively of CHI cases are extracted or whether, conversely, there is a high degree of overlap in cluster membership between CHI and healthy participants.

METHOD

Participants
Persons who had suffered a CHI requiring a period of in-patient care *(n* = 233; males = 172, females = 61) were recruited from referrals to four clinical neuropsychology services in the UK. Individuals were excluded if there was a pre-existing psychiatric or neurological disorder, a history of alcoholism/drug dependency or if they had not completed a full-length WAIS-R. The mean age of the participants was 32.3 years *(SD* = 13.07) and mean years of education was 11.7 *(SD* = 2.16). All participants were judged to have exited posttraumatic amnesia at the time of testing. The mean time elapsed between injury and testing was 33.4 months *(SD* = 23.29) with a median of 25 months. Because of the dificulties in assessing PTA, and differences across centers in their approach to its measurement, reasonable estimates of length of PTA could only be determined for 143 cases. Mean length of PTA was 21.9 days *(SD* = 31.57) with a median of 10 days. The percentage of cases for whom reasonable PTA data was available (61%) was similar to Crosson et al. (1990) (59%) as was mean length of PTA *(M* = 28.44 days).

A sample *(n* = 326) of participants drawn from the general adult population (GAP) was recruited as a control group. All potential participants were screened by interview to exclude those with known neurological, psychiatric, or systemic disorders, or a history of alcoholism/drug dependency. Participants were recruited from a variety of sources including community centers, recreational clubs and so forth. The mean age of the sample was 44.4 years *(SD* = 18.21 years) with a range from 16 to 84 years. The mean number of years of education was 11.83 years *(SD* = 2.75 years) with a range from 7 to 20 years. The social class of each subject was derived from their occupation, or former occupation, using the Classification of Occupations (OPCS, 1980). The recruitment strategy was intended to obtain a sample that was broadly representative of the adult population in the UK, with respect to the distributions of social class, age, and gender. A chi-square goodness-of-fit test revealed that the social class distribution in the present sample did not differ significantly from the UK census figures for the adult population, x^2 (4, N = 326) = 1.21, p > .05. The percentages in each social class band were as follows (the expected percentages based on the census figures appear in parentheses): 1 = 5.5 (5); 2 = 21.2 (23); 3 = 49.4 (48); 5 = 6.7 (6). A similar procedure was adopted to examine the representativeness of the sample in terms of age distribution. Nine age bands were formed, corre-

sponding to those adopted for the WAIS-R standardization sample, with the exceptions that the 16-17 and 18-19 age bands were combined (because of low expected frequencies) and the 70-74 age band was replaced with a 70+ age band. The percentage of subjects in each age band was as follows (the census-derived expected percentages based on the census figures appear in brackets): 16-19 = 6.1 (8.8); 20-24 = 10.4 (9.7); 35-44 = 17.2 (15.8); 45-54 = 14.4 (14.8); 55-64 = 13.8 (14.6); 65-69 = 7.4 (6.5); 70+ =11.0 (11.3). A goodness-of-fit test revealed that the sample and expected distributions did not differ significantly, X^2 (6, N= 326) = 4.09, p > .05. Finally, a goodness-of-fit test revealed that the gender distribution did not differ significantly from the census-derived distribution, x^2 (1, N = 326) = 0.01, p > .05.

Because potential differences in the results for the large healthy sample and the CHI sample could stem from demographic differences rather than neurological status, a subsample was drawn from the healthy sample to match the CHI sample in terms of age, gender ratio, and years of education *(n* = 117; males = 81, females = 36); this sample will hereafter be referred to as the MC (matched controls) sample. Mean age in the MC sample was 34.9 years *(SD* = 14.04) and mean years of education was 11.9 years (S£> = 2.21). *F* tests and *t* tests revealed that the CHI and MC samples did not differ significantly in terms of either the variances or means for age and education (all *ps* > .05). A chi-square test also revealed that the gender distribution did not differ significantly between the two samples, x^2 (1, N = 350) = 0.61, p > .05.

Procedure
All participants completed a full-length WAIS-R. Cluster analysis was performed on the age-graded subtest scores of the CHI sample using SPSS-X (SPSS Inc., 1988). The pattern of scores is of interest, rather than their overall levels; therefore, product-moment correlation is an appropriate similarity index as it is unaffected by participants' average scores. SPSS-X does not offer correlation as a standard linkage measure so an individual's mean subtest score was subtracted from each of his/her 11 subtest scores. Clusters based on these mean-adjusted scores were then formed using the cosine measure (which is available in SPSS-X) as the similarity index. This is equivalent to using the correlation link with the unadjusted scores. As in Crosson et al. (1990) amalgamation of clusters was determined by average linkage and was stopped when the fusion coefficient fell below 0.20. Cluster analysis was also performed using the same procedures with the healthy GAP and MC samples

individually and the combination of CHI and GAP *(N = 559)* and CHI and MC *(N = 350)* samples.

RESULTS

Cross-Validation of CHI Clusters

In analysis of the CHI sample the fusion coefficient fell below 0.20 after 11 clusters. In line with Crosson et al. (1990), and with the recommendations of Everitt (1980) and Morris, Blashfield, and Satz (1981), clusters with less than 10 members were not considered to represent a common enough pattern to warrant interpretation. Mean subtest scores for the five clusters in which membership exceeded 10 participants are presented in Figure 1. These five clusters contained 198 of the 233 CHI participants. A comparison of the rank ordering of the mean subtest scores for each of the clusters in the present sample with each of the clusters obtained by Crosson et al. (1990) was conducted as a means of assessing the correspondence between clusters across samples. This procedure revealed that all clusters in the present study exhibited multiple divergences from the rank order of subtests in each of the clusters obtained by Crosson et al. (1990). An anonymous referee suggested that this requirement of replicating rank order is too stringent a cross-validation criterion and suggested that replicating the highest and lowest subtest scores would provide broad evidence of correspondence. Using this criterion one of the present clusters (cluster 6) corresponded to one of the clusters (cluster 6) obtained by Crosson et al.; in both clusters Comprehension was the highest subtest and Digit Symbol the lowest.

Extent of Clustering and Cluster Differentiation in CHI versus Healthy Samples

Clusters sizes are sensitive to sample size, therefore, to compare head-injured and control samples, 10 random samples each containing 233 participants were drawn from the GAP sample (any pair of samples necessarily had at least 140 participants in common and were expected to have 167 in common). A cluster analysis was performed on each randomly selected control sample. The mean number of clusters formed was 11.4 with a minimum of 10 and a maximum of 13. The modal number of clusters was 11, the same as in the CHI sample. However, the mean number of clusters containing 10 or more participants was 8.4 with a minimum of 7 and a maximum of 10. The corresponding number of clusters in the CHI sample was only 5, and thus outside this range (although there were a further 2 clusters in the CHI sample that each contained 9 participants). Also, the number of participants contained in these 5 clusters was only 198 whereas, for the randomly drawn healthy samples, the number of participants contained in clusters of 10 or more members varied from 201 to 226.

To determine if CHI profiles were more differentiated from each other than those found in a healthy sample, within-cluster analyses of variance were performed with subtests as repeated measures in the CHI sample (i.e., 11 analyses of variance were performed). The same procedure was followed in the GAP and MC samples. In the GAP sample 13 clusters were obtained (so 13 analyses of variance were performed) and for the MC sample there were 8 clusters (giving 8 analyses of variance). Interest is in the differentiation *between* subtest scores *within* clusters. For any given cluster, the estimated variance of the subtest score effect can be obtained by subtracting the error mean square from the between-subtest scores mean square and then dividing this result by the number of participants in the cluster (e.g., see Ostle & Mensing, 1975, p. 377). The average subtest effect is zero, so the variance is a measure of their magnitude. For the CHI sample the variance of the subtest effects had a range of 0.91 to 3.60 with a mean of 1.83. In the GAP and MC samples the corresponding ranges were 1.22 to 3.12 and 1.18 to 2.61, respectively, with means of 1.85 and 1.95. Thus, there was considerable overlap between the ranges observed in the CHI and healthy samples. The means are also similar and two-sample t tests gave no evidence of a difference between the CHI sample and either healthy sample *(p > .2* in each case).
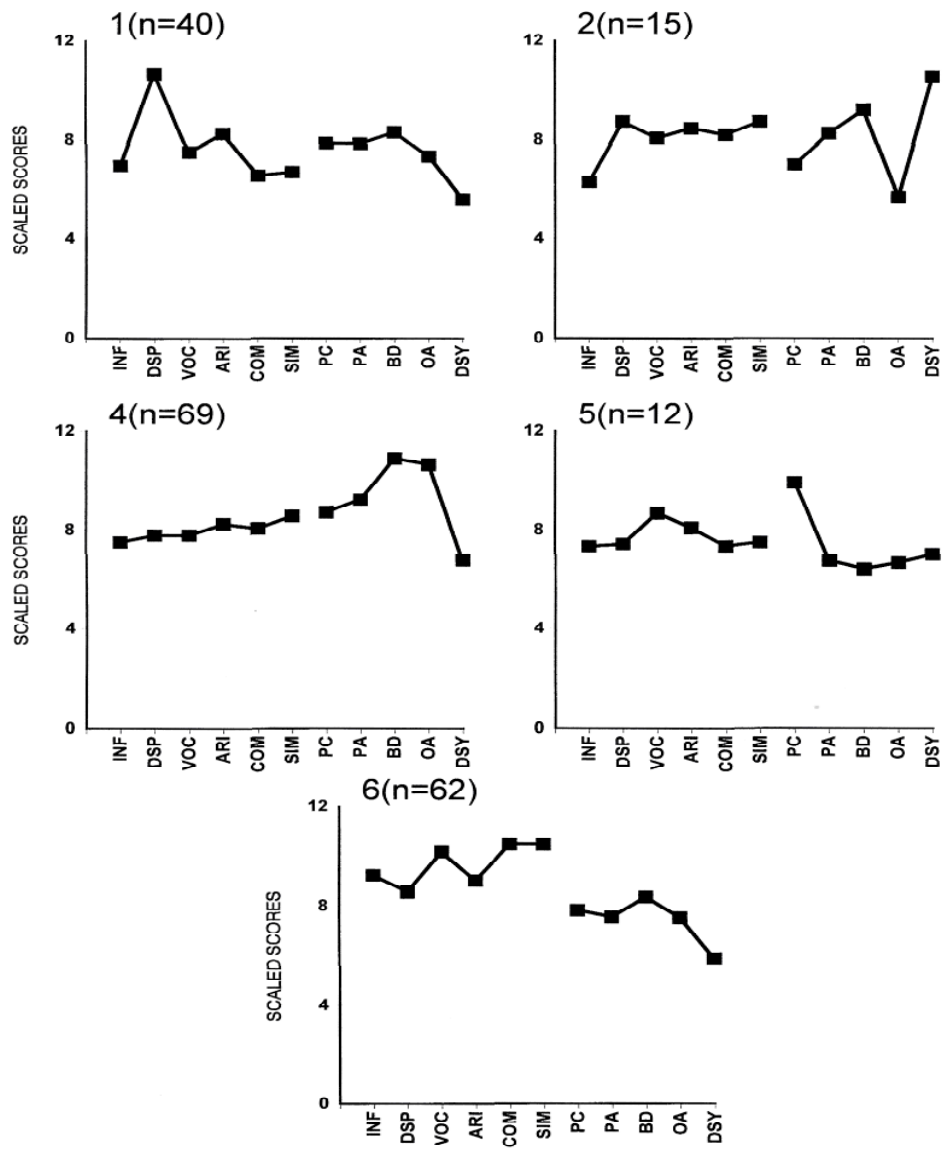
PATTERN CLUSTERS

Fig. 1.   Mean age-graded scaled scores for WAIS-R subtests in the five clusters with 10 or more CHI partici-
pants.

Role of Verbal/Performance Discrepancies in Formation of Clusters in the CHI Sample

Replicating Crosson et al. (1990), we formed composites consisting of the sum of age-graded scaled scores on the Verbal and Performance subtests. A two-factor analysis of variance (cluster by VIQ vs. PIQ with repeated measures on the latter factor) was performed. As found by Crosson et al. a highly significant interaction was obtained, $F(10,222) = 30.1$, $p < .0001$. Bonferroni tests were used to determine the number of clusters in which there was a significant difference between Verbal and Performance subtests. Significant differences were obtained for the two largest clusters *(p < .001 for each cluster)* but for the remaining nine clusters there was no evidence that the difference was non-zero *(p > .1 for each cluster).*

For comparison purposes two new arbitrary composites were formed in which subtests from the Verbal and Performance scales were equally represented in each. To further ensure that the composites had no inherent validity the pairs of subtests defining the WAIS-R perceptual organization (Block Design and Object Assembly) and freedom-from-distractibility factors (Arithmetic and Digit Span) were allocated to different composites. In addition, two of the four subtests defining the verbal factor were allocated to one composite (Information and Comprehension); the remainder (Vocabulary and Similarities) were allocated to the other (see Kaufman, 1990 for review of the factor structure of the WAIS-R).

A two-factor analysis of variance was again performed (cluster by arbitrary composite 1 vs. composite 2 with repeated measures on the latter factor). There was a highly significant interaction, $F(10,222) = 3.29$, $p < .0005$. Bonferroni tests revealed significant differences between the arbitrary composites for one of the clusters *(p < .001)* but not for the remainder *(p > .1)*. The effect size for the interaction involving VIQ versus PIQ was substantially larger $(r_|^2 = 0.0787)$ than the effect size for the interaction involving the arbitrary composites ($r_|^2 = 0.00627$).

Role of Verbal/Performance Discrepancies in Formation of Clusters in the Healthy Samples

The analyses used to investigate the role of Verbal/Performance discrepancies in the CHI sample were repeated with the clusters obtained in the healthy GAP and MC samples. In the GAP sample a significant interaction was obtained for cluster by VIQ versus PIQ, $F(\backslash 2, 313) = 19.02$, $p < .0001$ and also for cluster by arbitrary composite 1 versus composite 2, $F(\backslash 2, 313) = 11.2$, $p < .0001$. Bonferroni tests revealed a significant difference between Verbal and Performance subtests for 5 of the 13 clusters *(p < .05; p < .001 for 4 of the 5 clusters)*. Significant differences were also obtained for 6 of the 13 clusters when the arbitrary composites were compared (p<.05).

In the MC sample a significant interaction was obtained for cluster by VIQ versus PIQ, $F(7,109) = 12.9$, $p < .001$; a significant interaction was also obtained for cluster by arbitrary composite 1 versus 2, $F(7,109) = 7.9$, $p < .001$. Bonferroni tests revealed a significant difference between Verbal and Performance subtests for three of the eight clusters *(p < .01)*. Significant differences were also obtained for two of the eight clusters when the arbitrary composites were compared *(p < .05)*. These results are broadly similar to the results in the CHI sample.

Role of Neurological Status in the Formation of Clusters

Fourteen clusters were obtained from cluster analysis of the combined GAP and CHI samples *(N - 559)*; 13 of these clusters contained 10 or more members. The numbers expected in each cluster were determined under the null hypothesis that neurological status exerted no influence on cluster membership. These expected numbers and the observed numbers of CHI and healthy participants are recorded in Table 1. The numbers in clusters 1, 5, and 8 were combined so that expected numbers in each cell of the table exceeded 5. It can be seen from Table la that there was extensive overlap in cluster membership. However, a chi-square test comparing ob-

Table 1. Number of CHI and Healthy Participants in Clusters Obtained from Cluster Analysis of WAIS-R Subtest Scores for the Combined Samples.

1a. General adult population (GAP) and CHI samples combined ($N = 559$).

	Clusters											
	2	3	4	6	7	9	10	11	12	13	14	1,5,8
GAP	97 (84.0)	48 (37.3)	28 (20.4)	39 (54.2)	22 (42.6)	5 (7.0)	12 (15.2)	10 (8.7)	17 (12.8)	19 (18.7)	11 (8.2)	18 (16.9)
CHI	47 (60.0)	16 (26.7)	7 (14.6)	54 (38.8)	51 (30.4)	7 (5.0)	14 (10.8)	5 (6.3)	5 (9.2)	13 (13.3)	3 (5.8)	11 (12.1)

1b. Matched controls (MC) and CHI samples combined ($N = 350$).

	Clusters							
	1	3	5	6	8	9	10	2,4,7,11
MC	32 (23.7)	26 (31.1)	12 (8.7)	5 (5.0)	15 (9.4)	3 (5.0)	11 (21.7)	13 (12.4)
CHI	39 (47.3)	67 (61.9)	14 (17.3)	10 (10.0)	13 (18.6)	12 (10.0)	54 (43.3)	24 (24.6)

Note. Expected frequencies appear in parentheses.

served and expected numbers was highly significant, x^2(ll, $N = 559$) = 62.34, $p < .001$. The foregoing analysis was repeated for the combination of the CHI and MC samples. Eleven clusters were formed; all but one contained 10 or more members. Four clusters were combined so that the expected numbers in each cell exceeded 5. The observed and expected numbers are presented in Table Ib. There was extensive overlap and none of the clusters contained exclusively either CHI or healthy participants. However, a chi-square test comparing observed and expected numbers was significant, $y.^2$(7, $N = 350$) = 21.69, p<.01.

DISCUSSION

The analysis performed with the CHI sample in the present study suggests that the use of cluster analysis to identify subgroups of CHI clients on the basis of their WAIS-R performance does not produce replicable results. None of the subtest patterns exhibited in clusters obtained by Crosson et al. (1990) were exhibited in any of the clusters extracted in the present study. Correspondence between clusters in the rank order of subtest scores was used as the criteria of equivalence. This criteria is less stringent than possible alternatives that additionally factor in the magnitude of differences among subtests. Given the present indications that the cluster patterns in CHI are not replicable it would be inappropriate to comment on individual subtest patterns other than to note that few appear immediately meaningful or recognizable as common following a CHI. The exception to this is cluster 6 in the present study which was one of the two largest clusters extracted *(n - 62)*. This cluster resembles what clinical experience suggests would be the prototypical subtest pattern following a CHI in which Arithmetic and Digit Span are the most severely effected Verbal subtests and Digit Symbol is the most severely effected Performance subtest. As Lezak (1988) notes, "many persons who have suffered a mild concussion

with loss of consciousness tend to perform relatively poorly on Digits Backwards, Arithmetic and Digit Symbol" (p. 358). Although not fulfilling either of the two criteria for correspondence with this cluster, cluster 1 *(n = 10)* in the Crosson et al. (1990) study also exhibits this pattern.

The conclusion by Crosson et al. (1990) that Verbal/Performance discrepancies are important in the formation of clusters in CHI was evaluated in the present study. Replicating their findings, a significant cluster by VIQ versus PIQ interaction was obtained. However, it was demonstrated that the presence of a significant interaction alone is insufficient grounds for such a conclusion because this was also observed for composites that were intentionally formed so as to possess no inherent validity. Some support for the importance of Verbal/Performance discrepancies was provided by the difference in effect size between the interactions involving the Verbal/Performance and arbitrary composites although post hoc testing revealed that significant differences between VIQ and PIQ were obtained for only 2 of the 11 clusters.

The potential theoretical and practical significance of Verbal/Performance discrepancies was further examined by repeating the analyses conducted with the CHI sample in the healthy samples. The results were similar to those obtained in the CHI sample; a highly significant cluster by VIQ versus PIQ interaction was obtained in both healthy samples. As in the CHI sample, a significant interaction was also observed for the arbitrary composite but again the effect size was smaller. Thus, there is some support for the importance of Verbal/Performance discrepancies in the formation of clusters in CHI but it would appear that they are no more important in CHI than in healthy participants, that is, the results observed in the Crosson et al. (1990) and present CHI samples appear to have little to do with head injury per se.

The similarity in results for Verbal/ Performance discrepancies in the healthy and clinical samples in the present study raises the broader question of the extent to which the clustering in the CHI samples studied to date reflected characteristics of CHI. This question was examined by conducting a cluster analyses of the combined healthy and clinical samples. The chi-square test performed on the data in Table 1 indicated that the null hypothesis, that is, that neurological status exerted no influence on cluster membership, must be rejected. However, it can be seen that none of the clusters consisted exclusively of CHI or healthy participants and that there was a very high degree of overlap in membership between CHI and healthy participants for most clusters. It appears, therefore, that the presence versus absence of head injury was not a strong influence on the formation of clusters. This in turn suggests that clusters identified in CHI populations may be of limited diagnostic, prognostic, or localizing value because cluster membership may not reflect characteristics of head injury per se. Further indications that the results in the CHI sample of Crosson et al. (1990) and the CHI sample in the present sample do not specifically reflect characteristics of head injury is provided by the similarity between healthy and CHI samples in the degree of differentiation between clusters.

The CHI participants in the present study were recruited from amongst clients referred through routine channels to four, geographically diverse, clinical neuropsychology services. These features plus the large *n* (and correspondingly large *ns* for the healthy control samples) suggests that similar discouraging results may be expected in CHI populations serviced by other centers. Nevertheless, it would be prudent to defer judgment on the utility of the approach of Crosson et al. (1990) until further independent replication attempts have been made. In addition, in both studies to date the majority of CHI cases were relatively long-term survivors who would, therefore, be expected to have experienced recovery in WAIS-R performance from the acute period. It may be profitable to study the utility of cluster analysis in samples at an earlier stage of recovery.

In conclusion, as Crosson et al. (1990) note, the successful identification of meaningful subgroups of CHI cases would advance neuropsychological knowledge and contribute to improved clinical management. However, the present results suggest that these important aims are

more likely to be achieved through research strategies in which groups are formed a priori on the basis of theoretical considerations or empirical findings followed by attempts to validate the proposed distinctions.

REFERENCES

Bornstein, R . A. (1987). The WAIS-R in clinical practice: Boon or bust? *The Clinical Neuropsychologist, 1,* 185-190.

Crosson, B., Greene, R. L., Roth, D. L., Farr, S. P., & Adams, R. L. (1990). WAIS-R pattern clusters after blunt-head injury. *The Clinical Neuropsychologist, 4,* 253-262.

Everitt, B.S. (1980). *Cluster analysis* (2nd ed). London: Heineman Educational Books

Kaufman, A. S. (1990). *Assessing adolescent and adult intelligence.* Boston, MA: Allyn & Bacon.

Lezak, M. D. (1988). IQ: R.I.P. *Journal of Clinical and Experimental Neuropsychology, 10,* 351 -361.

Lezak, M. D. (1995). *Neuropsychological assessment* (3rd ed.). New York: Oxford University Press.

McKinlay, W. W., & Gray, J. M. (1992). Assessment of the severely head-injured. In J. R. Crawford, D. M. Parker, & W. W. McKinlay (Eds.), *A handbook of neuropsychological assessment* (pp. 363-378). Hove UK: Lawrence Erlbaum.

Morris, R. Blashfield, R., & Satz, P. (1981). Neuropsychology and cluster analysis: Potentials and problems. *Journal of Clinical Neuropsychology, 3,* 79-99.

Office of Population, Censuses and Surveys (1980). *Classification of occupations.* London: HMSO.

Ostle, B., & Mensing, R.W. (1975). *Statistics in research.* Iowa: Iowa State University Press.

Reitan, R. M., & Wolfson, D. (1990). A consideration of the comparability of the WAIS and WAIS-R. *The Clinical Neuropsychologist, 4,* 80-85.

Richardson, J. T. E. (1990). *Clinical and neuropsychological aspects of closed-head injury.* London: Taylor & Francis.

SPSS Inc (1988). *SPSS-X user's guide* (3rd ed.). Chicago: SPSS.

Walsh, K. W. (1991). *Understanding brain damage* (2nd ed.). Edinburgh: Churchill Livingstone.

Wechsler, D. (1981). *Manual for the Wechsler Adult Intelligence Scale-Revised.* New York: Psychological Corporation.